IMAGING RADAR POTENTIALS FOR EARTH RESOURCES*

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Abstract

The potentials of airborne and spacecraft borne imaging radars in earth resources applications are reviewed and discussed. The areas specifically addressed are: oceanography, coastal regions studies, glaciology, polar ice studies, geology, geomorphology and agriculture. The paper also addresses the main areas of emphasis for the next ten years.

Introduction

Imaging radars were developed in the late 50's for military applicatons. However strong interest has recently been generated in their application to earth resources evaluation and surveying. The imaging radar extends the available spectrum for two dimensional remote sensing to the microwave region with the unique property of being an active system. This eliminates the need of adequate lighting from the sun which is needed in the optical region of the spectrum. It also has the property of being able to operate in a spectral region insensitive to cloud coverage.

The imaging radar senses different surface parameters than passive microwave, infrared, visible or UV sensors therefore it is complimentary to these other sensors. The radar mainly maps the surface topography in a time-angle format and is sensitive to changes in the surface local slope, roughness and dielectric constant. This allows the radar to sense changes in the surface geology or agricultural coverage, to map an ice field, and to image ocean waves and surface patterns. This last capability was the main drive in including the imaging radar in the payload of the SEASAT 78 spacecraft. An imaging radar sensor is also under study for the Shuttle. In this brief paper, we review the above potentials and discuss the areas of emphasis for the next ten years.

Areas of Application

Oceanography and Coastal Regions

The imaging radar generates a two dimensional image of the roughness patterns on the ocean surface. Due to gravity and local wind, the population of capillary and small gravity waves is different on the forward and backward side of swells. This allows the radar to image wave patterns in the deep ocean (Figure 1) and next to the coast (diffraction, refraction, breaking, etc.). This also allows the radar to image oil slicks (Figure 2), wind slicks, surface fronts, current edges, and indirectly, internal waves (Figure 1).

The applications are numerous. Global mapping of wave patterns allows one to generate models and prediction needed for ship routing, weather prediction and physical oceanographic studies. Local mapping near coastal regions could be used in the studies of harbor locations, near shore structures, sediment transport, bathymetry, coastal erosion and oil pollution detection. These applications are some of the main objectives of the SEASAT 78 imaging radar experiment.

The quantitative interpretation of the radar image is still in its infancy. The radar images gives the wavelength, direction and pattern of surface waves. However, one critical question is: what is the relation, if any, between the brightness intensity in the radar image and the wave height spectrum? Could we derive a relation between the wave height, the local wind and the local change in the roughness thus radar backscatter?

Glaciology and Polar Ice

The polar regions are a fundamental part of the earth's heat engine, yet the way they interact with the atmosphere-ocean-ice-land system is poorly known because most of the previous experiments were directed toward local areas. Global experiments requiring airborne or spaceborne remote sensors have been undertaken recently, however the extensive cloud cover was a major observational barrier. This can be resolved with the use of the imaging radar as a compliment to photographic and radiometric sensors. Wide scale radar mapping could thus be used for ship routing, heat flux models, ice dynamics and iceberg tracking. This is also of economic importance in local areas like the Great Lakes.

The radar imager can also be used to survey the dynamics of glaciers and ice fields by taking imagery on a monthly or bimonthly basis. Figure 2 shows some radar imagery of glaciers in south-east Alaska.

Geology and Geomorphology

Radar imagery can be used for regionalization of landform units, identification of individual landform features and the determination of relative relief and slopes. These data have applications in geologic exploration, civil engineering, soil mapping, land use planning and water resources management. Landform units mapped with radar have been found to agree well with units derived from topographic maps. Exploration geologists have used the same surface features so evident on radar imagery for the location of possible mining sites.

A number of geologic exploration programs have been undertaken using imaging radars. For example, in 1971, Westinghouse undertook a SLAR survey of Nicaragua which led to the selection of areas where systematic search for mineralization is worthwhile. In 1972, radar mapping in south Venezuela, undertaken by Goodyear, led to new mineral finds of iron and possibly uranium.

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It should be emphasized that radar imagery does not specifically provide the location of mineral deposits. But it gives an added information, because of it's physiographic-geologic data content, to help geologists in locating areas where there is a high probability of finding mineral deposits. Work is still needed in the correlation between the locan tones and intensities in a radar image, and the surface nature (physical and mineral).

Research is also being done to evaluate the application of radars in a number of other fields: crop identification, flood mapping, soil type mapping, soil moisture monitoring, snow cover measurements and others. However these areas are still in their infancy and can not be covered in this short paper.

Finally we would like to point out that with the advent of SEASAT 78 and the Shuttle in the 80's, the imaging radar is going to be placed in the forefront of remote sensors for earth resources applications.

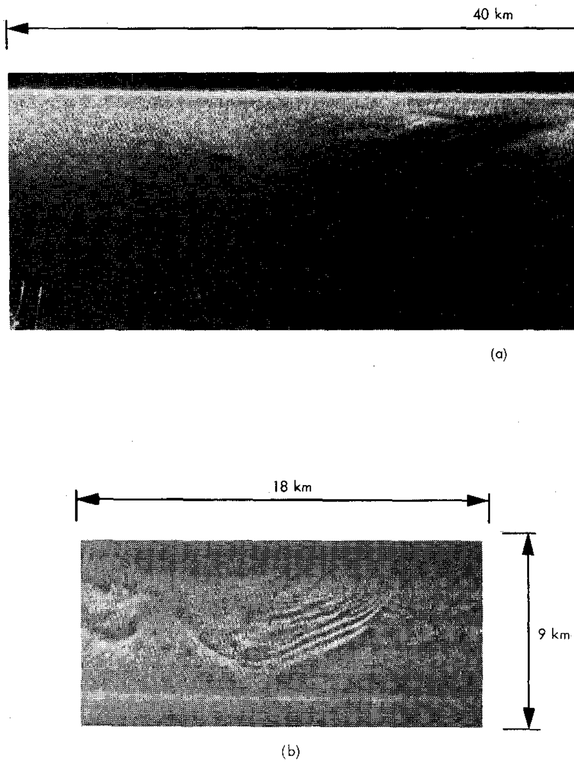

Figure 1. a) Surface swells and internal waves off the coast of Oregon. The entrance of Gose Bay is seen in the lower left corner. The swells have a 160 meter wavelength. The internal wave pattern, shown in b) after geometric correction and filtering consists of a few cycles with a 450 meter wavelength.

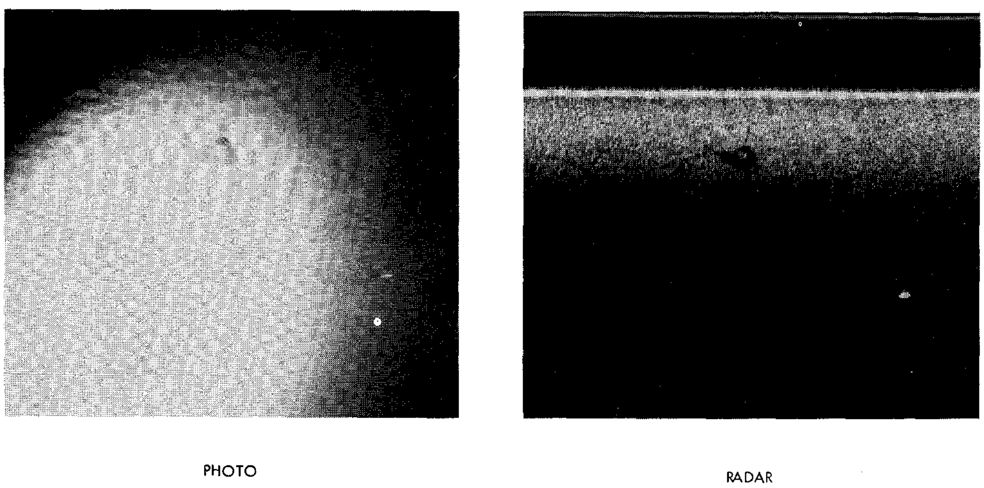

Figure 2. Radar and photo image of the same area where an oil slick, about 1.5 km wide, and a boat are visible.

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